DEFENSE ADVANCED RESEARCH PROJECTS AGENCY (DARPA)
14.B Small Business Technology Transfer (STTR) Program

1.1 INTRODUCTION

DARPA's mission is to prevent technological surprise for the United States and to create technological surprise for its adversaries. The DARPA SBIR and STTR Programs are designed to provide small, high-tech businesses and academic institutions the opportunity to propose radical, innovative, high-risk approaches to address existing and emerging national security threats; thereby supporting DARPA's overall strategy to bridge the gap between fundamental discoveries and the provision of new military capabilities.

The responsibility for implementing DARPA's Small Business Technology Transfer (STTR) Program rests with the Small Business Programs Office.

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
Attention: DIRO/SBPO
675 North Randolph Street
Arlington, VA 22203-2114
sbir@darpa.mil
Home Page http://www.darpa.mil/Opportunities/SBIR_STTR/SBIR_STTR.aspx

Offerors responding to the DARPA topics listed in Section 11.0 of the DoD 14.B STTR Solicitation must follow all the instructions provided in the DoD Program Solicitation. Specific DARPA requirements in addition to or that deviate from the DoD Program Solicitation are provided below and reference the appropriate section of the DoD Solicitation.

3.0 DEFINITIONS

3.4 Export Control

The following will apply to all projects with military or dual-use applications that develop beyond fundamental research (basic and applied research ordinarily published and shared broadly within the scientific community):

(1) The Contractor shall comply with all U. S. export control laws and regulations, including the International Traffic in Arms Regulations (ITAR), 22 CFR Parts 120 through 130, and the Export Administration Regulations (EAR), 15 CFR Parts 730 through 799, in the performance of this contract. In the absence of available license exemptions/exceptions, the Contractor shall be responsible for obtaining the appropriate licenses or other approvals, if required, for exports of (including deemed exports) hardware, technical data, and software, or for the provision of technical assistance.

(2) The Contractor shall be responsible for obtaining export licenses, if required, before utilizing foreign persons in the performance of this contract, including instances where the work is to be performed on-site at any Government installation (whether in or outside the United States), where the foreign person will have access to export-controlled technologies, including technical data or software.

(3) The Contractor shall be responsible for all regulatory record keeping requirements associated with the use of licenses and license exemptions/exceptions.

(4) The Contractor shall be responsible for ensuring that the provisions of this clause apply to its subcontractors.

Please visit http://www.pmddtc.state.gov/regulations_laws/itar.html for more detailed information regarding ITAR/EAR requirements.

3.5 Foreign National

Foreign Nationals (also known as Foreign Persons) means any person who is NOT:

a. a citizen or national of the United States; or
b. a lawful permanent resident; or
c. a protected individual as defined by 8 U.S.C. § 1324b

ALL offerors proposing to use foreign nationals MUST follow Section 5.4. c.(8) of the DoD Program Solicitation and disclose this information regardless of whether the topic is subject to ITAR restrictions. There are two ways to obtain U.S. citizenship: by birth or by naturalization. Additional information regarding U.S. citizenship is available at http://travel.state.gov/law/citizenship/citizenship_782.html. Definitions for "lawful permanent resident" and "protected individual" are available under section 3.5 of the DoD instructions.

4.0 PROPOSAL FUNDAMENTALS

PLEASE NOTE: Use of the DARPA SBIR/STTR Information Portal (SSIP) is MANDATORY. Offerors will be required to authenticate into the SSIP (via the DARPA Extranet) to retrieve their source selection decision notice, request debriefings, and upload reports (awarded contracts only). DARPA SBPO will automatically create an extranet account for new users and send the SSIP URL, authentication credentials, and login instructions AFTER the 14.B source selection period has closed. DARPA extranet accounts will ONLY be created for the individual named as the "Corporate Official" (CO) on the proposal coversheet. Offerors may not request accounts for additional users at this time.

4.6 Classified Proposals

DARPA topics are unclassified; however, the subject matter may be considered to be a "critical technology" and therefore subject to ITAR/EAR restrictions. See **Export Control** requirements above in Section 3.1.

4.10 Debriefing

DARPA will provide a debriefing to the offeror in accordance with FAR 15.505. The source selection decision notice (reference 4.4 Information on Proposal Status) contains instructions for requesting a proposal debriefing. Please also refer to section 4.0.

Notification of Proposal Receipt

Within 5 business days after the solicitation closing date, the individual named as the "Corporate Official" on the Proposal Cover Sheet will receive a separate e-mail from sbir@darpa.mil acknowledging receipt for each proposal received. Please make note of the topic number and proposal number for your records.

Information on Proposal Status

The source selection decision notice will be available no later than **90 days after solicitation close**. The individual named as the "Corporate Official" on the Proposal Cover Sheet will receive an email for each

proposal submitted, from sbir@darpa.mil with instructions for retrieving their official notification from the SSIP. Please read each notification carefully and note the proposal number and topic number referenced. The CO must retrieve the letter from the SSIP 30 days from the date the e-mail is sent. After 30 days, the CO must send a written request to sbir@darpa.mil to obtain the source selection decision notice. The request must explain why the offeror was unable to retrieve the source selection decision notice from the SSIP within the original 30 day notification period. Please also refer to section 4. 0 of the DoD Instructions.

4.13 Phase I Award Information

a. Number of Phase I Awards. The number of Phase I awards will be consistent with DARPA's budget, the number of anticipated awards for interim Phase I modifications, and the number of anticipated Phase II contracts. No Phase I contracts will be awarded until evaluation of all qualified proposals for a specific topic is completed. Normally offerors will receive their source selection decision notice for a Phase I proposal within 90 days of the closing date for this solicitation. Selections are posted at www.dodsbir.net/selections.
b. Type of Funding Agreement. DARPA Phase I awards will be Firm Fixed Price contracts.
c. Dollar Value. DARPA Phase I awards shall not exceed $100,000 for the base effort, or $105,000 for the base effort if technical assistance services are proposed, and shall not exceed $50,000 for the option if exercised.
d. Timing. Across DoD, the median time between the date that the STTR solicitation closes and the award of a Phase I contract is approximately four months.

4.22 Discretionary Technical Assistance (DTA)

Offerors that are interested in proposing use of a vendor for technical assistance must complete the following:

1. Provide a one-page description of the vendor you will use and the technical assistance you will receive. The description should be included as the LAST page of the Technical Volume. This description will not count against the 20-page limit of the technical volume and will NOT be evaluated.
2. Input the total proposed DTA cost under the "Discretionary Technical Assistance" line along with a detailed cost breakdown under "Explanatory material relating to the cost proposal" via the online cost proposal. The proposed amount may not exceed $5,000. You may also submit the detailed cost breakdown as an appendix to the one-page description. Label this appendix "DTA COST Breakdown" – it will not count against the 20-page limit of the technical volume.

Approval of technical assistance is not guaranteed and is subject to review of the Contracting Officer. Please see section 4.22 of the DoD instructions for additional information.

5.0 PHASE I PROPOSAL

Phase I Option

DARPA has implemented the use of a Phase I Option for 14.B STTR that may be exercised to fund interim Phase I activities while a Phase II contract is being negotiated. Only Phase I companies selected for Phase II will be eligible to exercise the Phase I Option. The Phase I Option covers activities over a period of up to four months and should describe appropriate initial Phase II activities that may lead to the successful demonstration of a product or technology. The statement of work for the Phase I Option counts toward the 20-page limit for the Technical Volume.

A Phase I Cost Volume ($155,000 maximum) must be submitted in detail online via the DoD SBIR/STTR submission system. Offerors that participate in this solicitation must complete the Phase I Cost Volume, not to exceed the maximum dollar amount of $100,000, or $105,000 if technical assistance services are proposed, and a Phase I Option Cost Volume, not to exceed the maximum dollar amount of $50,000. Phase I awards and options are subject to the availability of funds.

Offerors are REQUIRED to use the online Cost Volume for the Phase I and Phase I Option costs (available on the DoD SBIR/STTR submission site).

Human or Animal Subject Research

DARPA discourages offerors from proposing to conduct Human or Animal Subject Research during Phase I due to the significant lead time required to prepare the documentation and obtain approval, which will delay the Phase 1 award. See sections 4.7 and 4.8 of the DoD Instructions for additional information.

5.4 (6) Commercialization Strategy

DARPA is equally interested in dual use commercialization of STTR project results to the U.S. military, the private sector market, or both, and expects explicit discussion of key activities to achieve this result in the commercialization strategy part of the proposal. The discussion should include identification of the problem, need, or requirement relevant to a Department of Defense application and/or a private sector application that the STTR project results would address; a description of how wide-spread and significant the problem, need, or requirement is; and identification of the potential DoD end-users, Federal customers, and/or private sector customers who would likely use the technology.

Technology commercialization and transition from Research and Development activities to fielded systems within the DoD is challenging. Phase I is the time to plan for and begin transition and commercialization activities. The small business must convey an understanding of the preliminary transition path or paths to be established during the Phase I project. That plan should include the Technology Readiness Level (TRL) expected at the end of the Phase I. The plan should include anticipated business model and potential private sector and federal partners the company has identified to support transition and commercialization activities. In addition, key proposed milestones anticipated during Phase II such as: prototype development, laboratory and systems testing, integration, testing in operational environment, and demonstrations.

5.5 Phase I Proposal Checklist:

The following criteria must be met or your proposal may be REJECTED.

____1. Include a header with company name, proposal number and topic number to each page of your Technical Volume.
____2. Include tasks to be completed during the option period and include the costs in the Cost Volume.
____3. Break out subcontractor, material and travel costs in detail. Use the "Explanatory Material Field" in the DoD Cost Volume for this information, if necessary.
____4. The base effort does not exceed $100,000 or $105,000 if technical assistance services are proposed, and twelve months and the option does not exceed $50,000 and four months. The costs for the base and option are clearly separate, and identified on the Proposal Cover Sheet, in the Cost Volume, and in the statement of work section of the Technical Volume.
____5. The technical volume does not exceed twenty (20) pages. Any page beyond 20 will be redacted prior to evaluations.

____6. Upload the Volume 1: Proposal Cover Sheet; Volume 2: Technical Volume; Volume 3: Cost Volume; and Volume 4: Company Commercialization Report electronically through the DoD submission site by 6:00 AM (ET), October 22, 2014.
____7. After uploading your file on the DoD submission site, review it to ensure that all pages have transferred correctly and do not contain unreadable characters. Contact the DoD Help Desk immediately with any problems.

6.0 PHASE I EVALUATION CRITERIA

The offeror's attention is directed to the fact that non-Government advisors to the Government may review and provide support in proposal evaluations during source selection. Non-government advisors may have access to the offeror's proposals, may be utilized to review proposals, and may provide comments and recommendations to the Government's decision makers. These advisors will not establish final assessments of risk and will not rate or rank offeror's proposals. They are also expressly prohibited from competing for DARPA SBIR or STTR awards in the SBIR/STTR topics they review and/or provide comments on to the Government. All advisors are required to comply with procurement integrity laws and are required to sign Non-Disclosure and Rules of Conduct/Conflict of Interest statements. Non-Government technical consultants/experts will not have access to proposals that are labeled by their offerors as "Government Only".

Please note that qualified advocacy letters will count towards the proposal page limit and will be evaluated towards criterion C. Advocacy letters are not required. Consistent with Section 3-209 of DoD 5500.7-R, Joint Ethics Regulation, which as a general rule prohibits endorsement and preferential treatment of a non-federal entity, product, service or enterprise by DoD or DoD employees in their official capacities, letters from government personnel will NOT be accepted.

A qualified advocacy letter is from a relevant commercial procuring organization(s) working with a DoD or other Federal entity, articulating their pull for the technology (i.e., what need the technology supports and why it is important to fund it), and possible commitment to provide additional funding and/or insert the technology in their acquisition/sustainment program. If submitted, the letter should be included as the last page of your technical proposal. Advocacy letters which are faxed or e-mailed separately will NOT be accepted.

Limitations on Funding

DARPA reserves the right to select and fund only those proposals considered to be of superior quality and highly relevant to the DARPA mission. As a result, DARPA may fund multiple proposals in a topic area, or it may not fund any proposals in a topic area.

7.0 PHASE II PROPOSAL

All offerors awarded a Phase I contract under this solicitation will receive a notification letter with instructions for preparing and submitting a Phase II Proposal and a deadline for submission. Visit http://www.darpa.mil/WorkArea/DownloadAsset.aspx?id=2147487745 for more information regarding the Phase II proposal process.

11.0 CONTRACTUAL CONSIDERATIONS

11.1(r) Publication Approval (Public Release)

National Security Decision Directive (NSDD) 189 established the national policy for controlling the flow of scientific, technical, and engineering information produced in federally funded fundamental research at colleges, universities, and laboratories. The directive defines fundamental research as follows: "Fundamental research' means basic and applied research in science and engineering, the results of which ordinarily are published and shared broadly within the scientific community, as distinguished from proprietary research and from industrial development, design, production, and product utilization, the results of which ordinarily are restricted for proprietary or national security reasons."

It is DARPA's goal to eliminate pre-publication review and other restrictions on fundamental research except in those exceptional cases when it is in the best interest of national security. Please visit http://www.darpa.mil/NewsEvents/Public_Release_Center/Public_Release_Center.aspx for additional information and applicable publication approval procedures.

11.4 Patents

Include documentation proving your ownership of or possession of appropriate licensing rights to all patented inventions (or inventions for which a patent application has been filed) that will be utilized under your proposal. If a patent application has been filed for an invention that your proposal utilizes, but the application has not yet been made publicly available and contains proprietary information, you may provide only the patent number, inventor name(s), assignee names (if any), filing date, filing date of any related provisional application, and a summary of the patent title, together with either: (1) a representation that you own the invention, or (2) proof of possession of appropriate licensing rights in the invention. Please see section 11.4 of the DoD instructions for additional information.

11.5 Intellectual Property Representations

Provide a good faith representation that you either own or possess appropriate licensing rights to all other intellectual property that will be utilized under your proposal. Additionally, proposers shall provide a short summary for each item asserted with less than unlimited rights that describes the nature of the restriction and the intended use of the intellectual property in the conduct of the proposed research. Please see section 11.5 of the DoD instructions for information regarding technical data rights.

11.7 Phase I Reports

All DARPA Phase I awardees are required to submit reports in accordance with the Contract Data Requirements List – CDRL and any applicable Contract Line Item Number (CLIN) of the Phase I contract. Reports must be provided to the individuals identified in Exhibit A of the contract. Please also reference section 4.0.

DARPA STTR 14.B Topic Index

DARPA STTR 14.B Topic Descriptions

ST14B-001 TITLE: Understanding Robust Biological Systems

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop computational approaches to accurately model and predict the dynamics of multispecies biological networks to elucidate the fundamental design principles that lead to robust communities.

DESCRIPTION: Biology has traditionally been a highly empirical science, with an emphasis on qualitative, rather than quantitative methods. With the advent of mathematical and systems-level descriptions of biological processes, the field of computational biology is rapidly growing (Villaverde & Banga 2013). The availability of whole genome sequences and metabolic schemes has enabled the reconstruction of metabolic networks in hundreds of species. While progress has been made in modeling interactions at different scales in time and space (e.g. metabolism, signaling, gene regulation), the majority of approaches are largely limited to intracellular dynamics.

Robustness is defined as the capacity of a system to maintain function in the face of perturbations. Within a biological context, we see this behavior emerge in the form of mutations that provide organisms with advantageous phenotypes for survival in hostile environments (e.g. drug-resistant bacteria). With the exception of a few researchers, a generalized description of biological robustness has not been proposed (Kitano 2007, Rizk 2009). To design complex multispecies communities, we must first understand the mechanisms of resilience and adaptation that occur in nature. Elucidation of these fundamental principles will be necessary in the development of of next-generation therapeutics and biomaterials for improving warfighter health and readiness.

Recently, high-throughput reconstruction of metabolic networks from genome sequencing data has been accomplished for a diverse set of 130 bacterial organisms (Freilich & Ruppin 2011, Henry 2010). Frequently, metabolic modeling is used to predict the relative fitness of a cellular system by comparing activity under optimal conditions following perturbation (e.g. modification of growth media). In addition, stoichiometric-based models have provided predictions for metabolic interactions in a bacterial system (Wintermute & Silver 2010). These approaches must be expanded to model networks of higher complexity i.e. with an increased number of interacting species as found in natural environments.

The goal of this project is to develop a generalized theoretical framework for describing the key elements of microbial communities towards informing the design of robust multispecies consortia. For example, recent progress has been made in modeling metabolic networks to predict levels of competition and complementarity among 154 species in the microbiome (Levy & Borenstein 2013). Applications for this technology include tools for the rational design of microbiome therapeutics, functional biofilms, and robust microbial biomanufacturing.

PHASE I: Develop a concept for modeling multispecies networks for a specific application area that is relevant to the DoD. Perform a comprehensive survey of current approaches to modeling and predicting the behavior of microbial consortia. The Phase I deliverables will include a report that describes the foundation and necessary components for developing a model capable of elucidating the underlying forces that govern the structure of ecosystems in Phase II, and a detailed approach for model development in the form of a software development plan.

PHASE II: The Phase II deliverable is anticipated to consist of a comprehensive platform for modeling microbial consortia with the ultimate goal of elucidating the fundamental design principles of robust multispecies communities. The package shall demonstrate the following capabilities:
- Integrate large data sets from various sources (genomics, proteomics, metabolomics)
- Predict the range of environments a particular species may inhabit based on genotype
- Provide a quantitative description of the growth rate, metabolism, and community relationships (e.g. competition, cooperation)
- Predict viability of a synthetic microbial community in a representative natural ecosystem
- Measure the susceptibility of the community to invaders (e.g. cheaters, pathogens, phage)
- Predict the relationship between nutrition and the community structure

PHASE III: A fundamental understanding of the principles for the design of robust biological networks will enable key DoD capabilities such as therapeutics that integrate with the microbiota, and cooperative/competitive species that form functional biofilms and optimize the metabolic networks of biosynthetic organisms for improving yield in production of fuels and materials.

REFERENCES:
[1] S Freilich & E Ruppin. Toward the educated design of bacterial communities. In Beneficial Microorganisms in Multicellular Life Forms, 2011.

[2] CS Henry et al. High-throughput generation, optimization and analysis of genome-scale metabolic models. Nat. Biotech., 2010.

[3] H Kitano. Towards a theory of biological robustness. Mol. Syst. Biol., 2007.

[4] R Levy & E Borenstein. Metabolic modeling of species interaction in the human microbiome elucidates community-level assembly rules. Proc. Nat. Acad. Sci., 2013.

[5] A Rizk, G Batt, F Fages, & S Soliman. A general computational method for robustness analysis with applications to synthetic gene networks. Bioinformatics, 2009.

[6] AF Villaverde & JR Banga. Reverse engineering and identification in systems biology: strategies, perspectives and challenges. J. R. Soc. Interface, 2014.

[7] E Wintermute & P Silver. Emergent cooperation in microbial metabolism. Mol. Syst. Biol., 2010.

KEYWORDS: Systems Biology, Metabolic Networks, Complex Adaptive Systems, Biological Robustness, Flux Balance Analysis, Mutualism, Microbiome

ST14B-002 TITLE: Chemical Ligands and Receptors for Engineering Biology

TECHNOLOGY AREAS: Chemical/Bio Defense, Biomedical

OBJECTIVE: Develop a high-throughput platform to rapidly identify sensors highly specific to small molecules or other ligands and use this platform to identify both novel ligands and their respective sensors for use in controlling biological circuitry.

DESCRIPTION: Advances in synthetic biology and the engineering of complex networks into biological systems have highlighted the need for precision control of gene expression at various mechanistic stages within the cell, e.g., transcription, translation, and metabolism. Recently the incorporation of Boolean logic into gene circuits has demonstrated how unique input signals could be used for actuation. [3]. Precision tuning of a system through the use of multiple layered circuits, or timed control generated by a tiered effect may achieve desired functions. Complex networks that rely on a number of unique input signals could be developed to allow for custom control, where each specific input ligand and respective sensor functionality together is dependent on various external or internal factors. Improving upon the response to a given input signal could allow for discrete control of engineered organisms used for manufacturing, medical countermeasures or new materials as well as "smart" organisms that have a sense-and-respond capability. In addition these ligand and sensor complexes may be useful for biosafety and biosecurity applications through engineered auxotrophy or induced lethality for containment of organisms [2].

Although research to date on circuit design has demonstrated a proof-of-concept ability to achieve levels of control of biological systems, 100% binary control has presented challenges due to off-pathway interactions, costs of chemical ligands, incomplete cellular uptake and/or chemical metabolism/toxicity, and lack of specificity of sensors and their expression levels leading to "leakiness" of the systems. New ligand and sensor complexes are needed that overcome some of these limitations, to allow for expansion of biological circuitry and control significantly beyond the current capability of biological engineering. These ligands and respective sensor systems should be able to

achieve appropriate orthogonality within a biological system and demonstrate utility across a range of hosts. The goal is to support development of a general high-throughput combinatorial platform approach for identification of sensors for novel ligands that exhibit stringent control in biological circuits without having a negative impact on the host chassis.

PHASE I: Develop an approach (e.g., platform/screen) to identify novel ligand and associated sensors for control of gene circuitry. Ligands may consist of small molecules, peptides, nucleic acids or other biological molecules. One should develop a platform that can identify "On" and "Off" ligand-sensor systems, with a goal to not only use the platform to identify novel ligands and their sensors but eventually to develop a screen for identification of a sensor for any given ligand molecule. The approach and screen should not only identify appropriate ligands but also support rapid assessment of relevant sensors, challenging the orthogonality of different pairs and also assessing fitness effects on industrial-relevant strains (e.g., strains with biosynthetic pathways).

The Phase I deliverable will be a final report that outlines the approach for high-throughput identification of multiple ligand and sensor systems, and that describes how the screen will carefully account for the challenges due to off-pathway interactions, costs of chemical ligands, incomplete cellular uptake and/or chemical metabolism/toxicity, and lack of specificity of sensors and their expression levels that may lead to "leakiness" of the systems. In addition, the performer will need to develop the genetic circuitry for the screen and demonstrate its functionality with a known ligand and associated sensor, to achieve tight (non-leaky) control of the system, and demonstrate that the system does not impose a fitness burden on the host cell.

PHASE II: The Phase II deliverable is a report that describes the identification of at least 100 novel ligands and associated sensors from utilization of the platform approach and screen developed in Phase I or an already established platform. Included data should demonstrate effectiveness of the ligand and sensors in complex circuitry, utilizing different novel ligand and sensor components in a cell at one time, operating simultaneously or in sequence. Each sensor should individually demonstrate stringent control (no leakiness) in an industrial relevant organism and the integrated circuit should operate without impact on 1) production of the biosynthetic product, or 2) fitness of the organism.

The ligands and sensors should also be used together in a single genetic circuit to demonstrate effectiveness in at least two host systems across two kingdoms (e.g., bacteria, yeast and mammalian cells) and, within the complex circuit, demonstrate effectiveness in precise timing and cascade control of functionality. Orthogonality of each of the ligand and sensor with other ligand and sensors should be tested as well as off-target effects within the host genome. Ligands identified should take into consideration the cost that is industrially relevant for large scale cell-production systems and should also not be toxic to the cell chassis. It is critical to demonstrate cellular dependence on these systems with reversion at frequencies below 10^-8.

PHASE III: The use of these ligands and sensors will expand upon the utility of a toolbox for engineering biology. These sensors could be leveraged for intrinsic bio-containment addressing biosafety and biosecurity issues of pathogenic organisms and/or reduce potential for bio-espionage by creating dependency on exogenously added compounds. In addition, such sensor systems may have implications in optimizing strains to sense certain metabolites or report on cell status. The ability to rapidly generate sensors for use in in vivo cell systems will be transformational to the synthetic biology field.

Although the democratization of the synthetic biology field is allowing many biological parts to become readily available, it is envisioned that the commercial sector will utilize such tailored ligand and sensor pairs uniquely with industrial production organisms for safety, complexity of biological control and/or optimization of the system.

REFERENCES:

[1] Chou, HH, and Keasling, JD (2013). Programming adaptive control to evolve increased metabolite production Nature Communications 4 (2595).

[2] Moe-Behrens, GH, Davis, R and Haynes, KA (2013). Preparing synthetic biology for the world. Frontiers in Microbiology 4(5) 2-10.

[3] Suiti, P, Yazbek, J, and Lu, TK (2013). Synthetic circuits integrate logic and memory in living cells. Nature Biotechnology 31 (5): 448-52.

KEYWORDS: Synthetic biology, genetic engineering, sensors, ligand-receptors

ST14B-003 TITLE: Robust and Adaptable Visual Scene Understanding

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop feed-forward and feed-back mechanisms for combining visual inputs with expectations regarding scene content and composition. Construct a machine vision system that uses these mechanisms to demonstrate scene understanding of images or video.

DESCRIPTION: Most computer vision systems built today are purpose-built, narrowly focused and brittle. Their performance is often highly sensitive to lighting, prone to errors in image segmentation and object detection, very limited in descriptive power, and difficult to repurpose or expand to larger problems. This is in stark contrast to animal vision systems which can function across varied lighting situations, are typically very robust at detecting objects and separating foreground from background, and are useful for widely varying tasks. While machine vision systems can outperform animal vision systems for specific, narrowly defined tasks, there is presently no machine system with an adaptability that even approaches that of animals.

This topic is looking for new approaches to visual scene understanding focused primarily on robustness and adaptability. Rather than bespoke machine vision systems that rely on tightly controlled and constrained operating conditions, the goal is to develop and demonstrate an approach that is readily adaptable to disparate tasks; can perform object detection and semantic classification in complex scenes; and is robust to lighting and perspective variations, errors, and noise in the inputs. For the warfighter these new approaches are expected to lead to systems that perform well in the field as well as the lab and can be readily repurposed to different tasks while reusing algorithms and sensors. Applications could include improved systems for Intelligence, Surveillance, Reconnaisance (ISR); Automated Target Recognition (ATR); and improved robotic autonomy.

Because animal visual systems exhibit many of the properties desired, approaches that build on concepts from, and models of, such systems are of particular interest. Neural network and biomimetic approaches are not sought, but approaches that exploit bi-directional information flows between sensors and classifiers in visual systems (e.g., attention mechanisms, detection biasing based on expectations) are of particular interest.

PHASE I: Produce an architecture and high-level design of the system that will be constructed. Identify the algorithms to be developed/adapted and where they fit in the design, the types of visual media that will be employed, the metrics by which the technology will be evaluated, and the level of performance against those metrics expected by the end of Phase II. Describe each of these elements in detail in the final report.

PHASE II: Construct a working prototype based on the high-level design that incorporates all key components of the proposed approach. Evaluate the prototype using data acquired under realistic conditions (e.g., varying light levels, multiple perspectives, etc.) and measure its performance against the metrics defined in Phase I. Demonstrate that the approach can be adapted to multiple challenges and is more than a custom-built system that cannot be adapted to new problem domains. Phase II deliverables are a demonstration of the working prototype and a final report. The final report should describe the as-built architecture and design of the prototype, the results of the prototype evaluation, and a description of future work needed to mature the technology to a point suitable for use in commercial and/or DoD applications.

PHASE III: DoD applications include automated surveillance, obstacle recognition and object classification for autonomous system, and intelligence analysis of imagery and video. Commercial applications are expected to include security systems, automated classification and discovery of images and video, robotic vision, and traffic monitoring.

REFERENCES:
[1] “Sequence seeking and counter streams: a computational model for bidirectional information flow in the visual cortex”, Shimon Ullman, Cerebral Cortex, 5(1):1–11, 1995. Weblink updated 9/9/14: ftp://publications.ai.mit.edu/ai-publications/pdf/AIM-1311.pdf

[2] “Tracking-learning-detection”. Zdenek Kalal, Krystian Mikolajczyk, and Jiri Matas, IEEE Transactions on Pattern Analysis and Machine Intelligence, 34(7):1409–1422, 2012. (http://epubs.surrey.ac.uk/713800/1/Kalal-PAMI-2011(1).pdf)

[3] "Auto-context and its application to high-level vision tasks and 3d brain image segmentation", Z. Tu and X. Bai, IEEE T-PAMI, vol. 32, no. 10, 2010. (http://pages.ucsd.edu/~ztu/publication/pami_autocontext.pdf)

[4] "Modeling the shape of the scene: a holistic representation of the spatial envelope", Aude Oliva and Antonio Torralba, International Journal of Computer Vision, Vol. 42(3): 145-175, 2001. (http://cvcl.mit.edu/Papers/IJCV01-Oliva-Torralba.pdf)

KEYWORDS: computer vision, image processing, scene recognition, scene understanding, object recognition, image segmentation, gisting

ST14B-004 TITLE: Revolutionary Airlift Innovation

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.4 of the solicitation.

OBJECTIVE: Develop and demonstrate novel concepts to generate conventional airlift-equivalent lift (ton-miles/hr) without requiring manned airlift, airports, or air superiority in a time constrained scenario.

DESCRIPTION: The Second World War proved the utility of gliders for cost-effective airlift of troops and materiel into combat zones without the need for runways. In postwar years, gliders were largely eclipsed by helicopters that travelled farther, were recoverable, and offered modern navigation and control equipment for more accurate landings in all weather conditions. Recent advances in tough, low-cost, lightweight materials, compact avionics and GPS navigation systems have revived glider research and development, particularly in naval Ship to Objective (STOM) logistics. This project seeks to develop and demonstrate novel concepts for high-throughput, low-cost, glider-based STOM airlift (ton-miles/hr) without the need for personnel, air base infrastructure, or air superiority in time constrained scenarios.

In this approach autonomous gliders would be directly launched from off-shore logistics ships. The following technical challenges must be investigated. First, the system must be designed such that a single use (relatively low cost) glider (essentially a flying cargo pallet) could gain sufficient altitude such that traditional shore-based Reception, Staging, Onward Movement, and Integration (RSOI) logistics depots could be overflown and bypassed, ferrying a variety of supply classes directly to the point of need with an order of magnitude cost reduction. Second, an all-weather launch platform must be designed that would enable scalable parallel sorties for high system throughput. Lastly, the system must be configured to be stowed in standard shipping containers, and unloaded with minimal effort, thereby eliminating the need for logistical support vehicles at the point of use.

This concept is not intended for heavy (such as vehicles) or for personnel lift, but rather for scaled sustainment operations for a deployed unit in unimproved areas (with individual payload weight and volume less than a standard 463L cargo pallet). Current platforms such as helicopters and transport aircraft conduct effective and responsive logistics sustainment operations, but delivery performance (as measured by a throughput cost metric of ton-

miles/hour/$) may be inhibited by lack of air assets, number of deployed units or areas to service, or lack of supporting infrastructure, such as may occur after a wide-spread natural disaster.

Glider systems would be designed, prototyped and characterized for performance in scaled land-based validation experiments and sea trials.

PHASE I: Create a detailed system design and demonstrate how the proposed system would achieve the logistics mission and maximizes throughput cost (ton-miles/hr/$) assuming up to 50 launches per hour from a ship. Describe these elements in detail in the final report.

PHASE II: Prototype key components of the proposed system and characterize in land-based testing. Validated components would be integrated in a scaled prototype which would undergo limited integrated testing. Phase II deliverables would be a preliminary design review and a scaled prototype vehicle and launch system.

PHASE III: Speed of production and system use-cost characterization and reduction would be explored as part of commercialization. The proposed system would be applicable to a variety of sea-based logistics operations. The proposed system would be applicable to the commercial logistics industry, and to humanitarian assistance and disaster relief operations.

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